Mortality Factors Affecting *Eurosta solidaginis* (Diptera: Tephritidae)[1]

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Abstract: The degree of parasitism of *Eurosta solidaginis* (Fitch) by *Eurytoma gigantea* Walsh and *E. obtusiventris* Gahan and of predation upon these species by birds was verified. Gall height positively influenced bird predation and parasitism by *Eurytoma obtusiventris*, whereas gall diameter was significantly related to bird predation and parasitism by *Eurytoma gigantea*. Multiple galls were favored by birds. The late summer emergence of *E. gigantea* was substantiated.

INTRODUCTION

The goldenrod ball gall fly, *Eurosta solidaginis* (Fitch), its parasites *Eurytoma gigantea* Walsh and *E. obtusiventris* Gahan (Hymenoptera: Eurytomidae), the so-called "accidental" predator *Mordellestina unicolor* Lec. (Coleoptera: Mordellidae), and the predation upon these species by birds have been studied for over a century. Life history and distributional data are plentiful (see Hughes, 1934; Uhler, 1951, 1961; Miller, 1959), but information on gall height and diameter in relation to parasitism or predation and data on larval and pupal biomass is lacking. This paper reports on unknown aspects of the biology of *Eurosta solidaginis* and its parasites and predators, with emphasis on mortality factors in relation to multiple galls, gall diameter, and gall height.

METHODS AND MATERIALS

In February 1975, 581 *Eurosta solidaginis* galls were collected from the stems of *Solidago canadensis* var. *scabra* (Muhl) T. & G.[2] in an abandoned field on the outskirts of Syracuse, N.Y. Two separate collections of the galls were made in a 3600 sq m area, utilizing a square meter grid random sampling method. Within this area, the gall density was 3.4 galls per sq m. The galls were placed in a

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[2] Specimens have been deposited in the S.U.N.Y. College of Environmental Science and Forestry Herbarium.

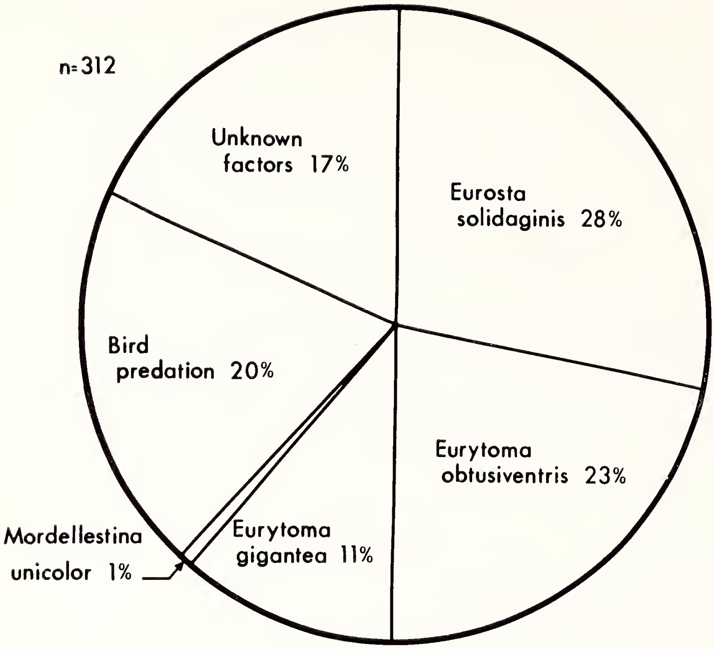

FIG. 1. Mortality factors (in pct) for a population of *Eurosta solidaginis* from Syracuse, N.Y. (Determined from overwintering galls).

Sherer environmental control chamber and subjected to a series of gradual temperature increases designed to parallel field temperatures for that time of year. Humidity was maintained at 76 ± 2° by placing the galls inside airtight 1-gal. glass jars, each containing a 1 oz cup of saturated NaCl solution. Galls from one collection were later transferred to 4 oz plastic containers for emergence studies. Galls from the other collection were dissected during February and March for larval and pupal biomass studies. In the latter studies the larvae were removed from the galls, placed in a container under optimal humidity conditions, and periodically observed, measured, and weighed. Overwintering host and parasite larvae that were removed from their galls and subjected to suitable humidity and temperature treatments developed concurrently with undisturbed galls. The exposed insects yielded living adults a day in advance of the undisturbed galls.

In all cases, gall height was measured along the stem from the ground surface to the gall base. Gall diameter was taken as the widest axis of the gall perpendicular to the stem. Statistical significance of the results was determined through combined application of Student's t, F distribution, Chi-square and classed Chi-square statistical analyses (see Snedecor, 1956). Null hypothesis rejection was set at the 95% level of confidence.

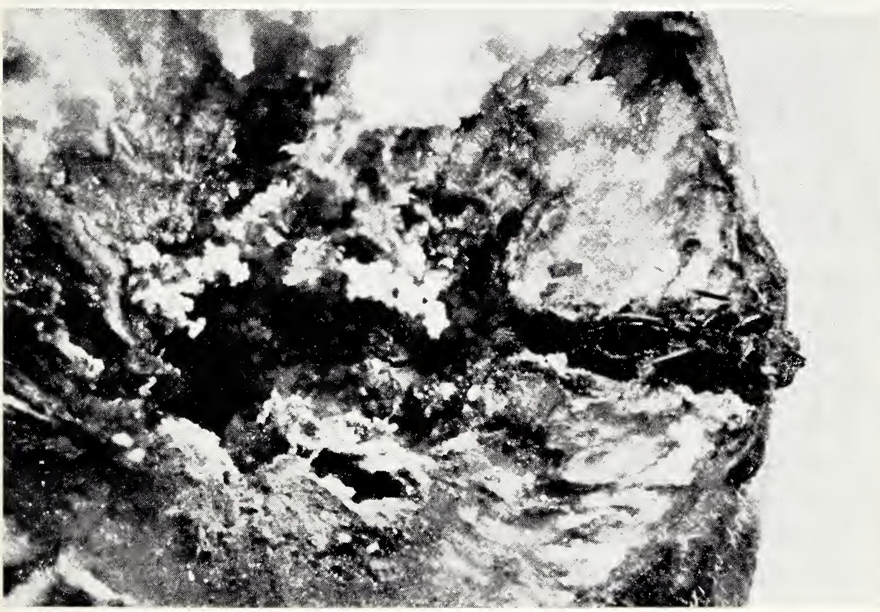

Fig. 2. Gall of *Eurosta solidaginis* showing characteristic downy woodpecker predation.

Fig. 3. Adult *Eurytoma gigantea* emerging in the field from late summer gall.

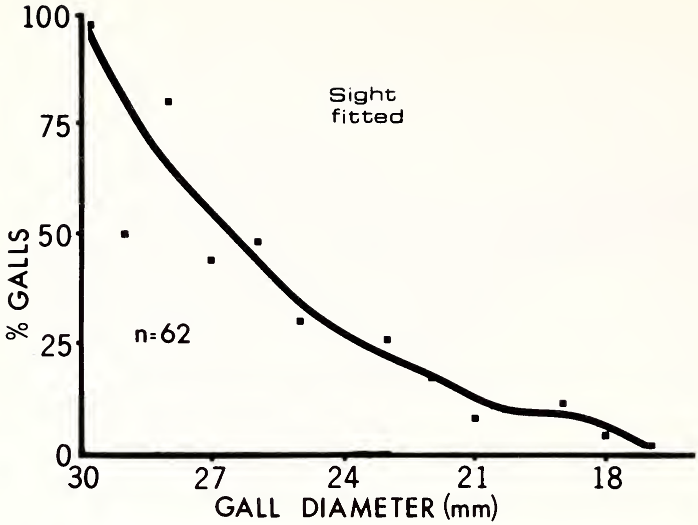

FIG. 4. Percent galls attacked by birds plotted against gall diameter in mm.

RESULTS

Parasitism of *Eurosta solidaginis* by *Eurytoma gigantea* and *E. obtusiventris* was confirmed (fig. 1). Double parasitism, involving the gall cavity being occupied by single individuals each of *Eurytoma gigantea* and *E. obtusiventris*, was rare—2 of 538 galls or 0.4%. In such cases, adults of both species developed and emerged normally. Only 0.6% of the galls that were opened contained larvae or adults of the mordellid *Mordellestina unicolor* Leconte. In one gall cavity, the beetle larva had consumed a larva of the parasite *Eurytoma obtusiventris*, as evidenced by its empty pupal case, while another gall produced living adults of both *M. unicolor* and *Eurosta solidaginis*.

We verified Milne's (1940) suspicions that the Downy Woodpecker, *Dendrocopus pubescens* (Swainson), is a major predator by observing individuals of this species attacking galls in late October 1974 and 1975. The act of locating and opening the gall and feeding upon the larva of *Eurosta solidaginis* often took less than 30 sec, resulting in a roughly conical depression leading into the central cavity of the gall (fig. 2). If the gall cavity contained a larva of *Eurytoma obtusiventris*, however, it was often not consumed.

The numbers of *Eurosta solidaginis* that emerged and were sexed comprised roughly equal numbers of males and females. Both pupation and emergence of the host species preceded that of either *Eurytoma* species. Adults of *E. gigantea* were the last of the three species to emerge under laboratory conditions.

All individuals of *E. obtusiventris* that were reared and collected in connection

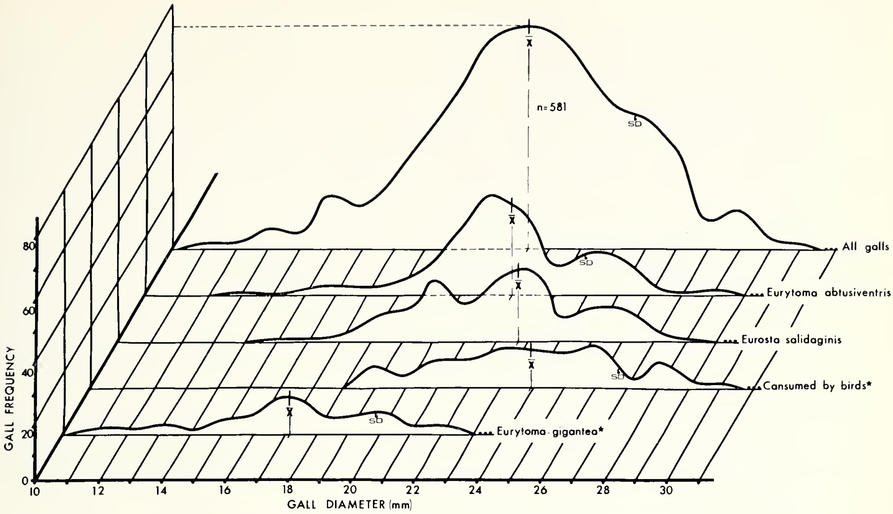

FIG. 5. Frequency curves for gall diameter in mm. Mean ($\bar{x}$) and standard deviation (SD) are shown for each curve. * indicates statistical significance at the 5% level.

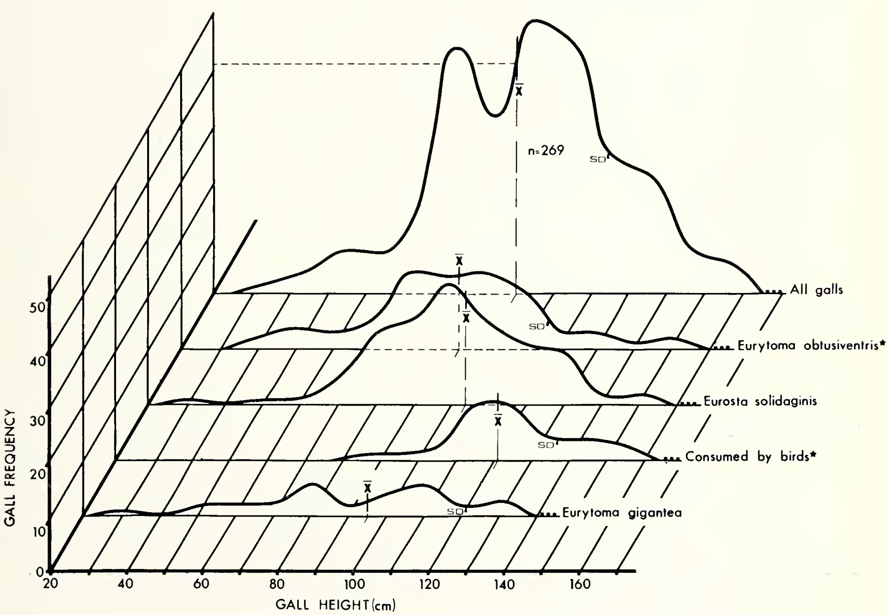

FIG. 6. Frequency curves for gall height in cm. Mean ($\bar{x}$) and standard deviation (SD) are shown for each curve. * indicates statistical significance at the 5% level.

with our study were females. The larvae of these parasites overwintered inside the smaller premature host pupae.

Approximately half of the galls which contained *E. gigantea* were involved in late summer emergence in 1975 (fig. 3).

Multiple galls[3] were fed upon more by birds than were single galls. The incidence of either parasite species was, in contrast, not related to multiple versus single galls.

Gall diameter was related to both predation by birds and parasitism by *Eurytoma gigantea* (fig. 4, 5). Galls higher on the stems were fed upon proportionately more by birds, whereas galls lower on the stems were parasitized more significantly by *E. obtusiventris* (fig. 6). Galls whose cavities were occupied by *E. gigantea* were also located lower on the stems but borderline t and F values coupled with large SE_M were inconclusive.

No significant correlations between larval masses of *Eurosta solidaginis*, *Eurytoma gigantea* or *E. obtusiventris* and gall diameter or height were found.

DISCUSSION

The rather similar percentages of parasitism reported by Hughes (1934), Uhler (1951) and Miller (1959) and observed by us for *Eurytoma gigantea* and *E. obtusiventris* on *Eurosta solidaginis* emphasize the fact that these three species have attained a dynamic equilibrium in their relationships. The rare instances of double parasitism indicate that, at times, both *Eurytoma gigantea* and *E. obtusiventris* can coexist within the same gall cavity. The very low percentage of the commensal but occasional predator, *Mordellestina unicolor*, that we encountered in our study may be incidental to the ecology of the study area. Both Hughes (1934) and Uhler (1951) reported a much higher incidence of *M. unicolor* within the gall cavity of *Eurosta solidaginis*.

The relatively high amount (20%) of bird predation which we found had been surpassed only by the rather high (44.8%) mortality reported by Milne (1940). Uhler (1951, 1961) and Miller (1959) noted much lower instances of bird predation. The relatively high degree of mortality via bird predation that we observed may be related to the proximity of a wooded cemetery and hedgerow surrounding the study area, both of which supported large bird populations.

The fact that the larva of *Eurytoma obtusiventris* was often not consumed whereas those of *E. gigantea* and *Eurosta solidaginis* were invariably eaten by birds is puzzling. The position of the parasitic *Eurytoma obtusiventris* inside the puparium of its host may provide a negative stimulus to the bird predator, whereas that of the host larva may be attractive. Furthermore, the "varnish-like" coating on the walls of the gall cavity, which is associated only with *Eurytoma*

[3] More than one *Eurosta solidaginis* gall on a single goldenrod stem.

obtusiventris, may be distasteful or act as a repellent to the bird predator, as suggested by Milne (1940).

The results of our emergence studies concur with those of Hughes (1934), Uhler (1951), and Miller (1959), i.e., adults of *Eurosta solidaginis* emerge first followed by those of *Eurytoma obtusiventris* and later, *E. gigantea*. Although Uhler (1951, 1961) contended that *E. gigantea* has only a single emergence period per year, our studies confirm those of Miller (1959) and indicate that there are two emergence periods annually; one in late summer, the other in late spring. We found that approximately equal numbers of adults were involved in the two emergences, whereas Miller (1959) reported that three-fourths of his Ohio population of *E. gigantea* emerged during the spring. The advantages and disadvantages of the "early" and "late" emergences of this parasite have not been ascertained.

Multiple galls were fed upon significantly more by birds than were single galls. It would be advantageous for birds to concentrate their feeding on multiple galls because they could consume more larval *Eurosta solidaginis* with less searching. Thus, multiple galls may be visually more attractive to birds than single galls. Similarly, galls of greater diameters and those higher on the stem were fed upon more by birds because they are more easily recognized visually and are more easily accessible.

Galls occupied by *Eurytoma gigantea* were rarely the object of bird predation due, we believe, to their reduced gall diameters. Such undersized galls were first noted by Johannsen (1910). Since the larva of *Eurosta solidaginis* apparently produces the gall-forming hormone(s) and the rather rapid attack on this host by the external parasite *Eurytoma gigantea* occurs when gall growth is only 65% completed (Uhler, 1951), *E. gigantea* must interfere with the host larva's ability to produce gall-forming hormone(s) resulting in an undersized gall. The slower, internal type of parasitism of *Eurytoma obtusiventris* does not influence gall formation at an early stage, resulting in a full-sized, completed gall.

Galls lower on the stems were attacked less often by birds but were parasitized more frequently by *Eurytoma obtusiventris*. In the former case we believe that a negative visual stimulus is involved. *E. obtusiventris* may be associated with galls lower on the stems because of its small size, its weak flight capacity and its inability to cope with strong wind. Uhler, on the other hand, has indicated (pers. comm.) that because both oviposition by *Eurosta solidaginis* and subsequent parasitism by *Eurytoma obtusiventris* takes place early in the season none of these factors would be important.

Gall diameter or height and larval mass show no significant correlations, suggesting that bird predation does not exert a significant pressure on the mass of *Eurosta solidaginis* or its parasites. Thus, inherent plant factors such as tissue and sap production may be ultimately responsible for the final larval mass.

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BOOK REVIEW

Mosquito ecology: Field sampling methods. M. W. Service. 583 pp. Hallstead Press—John Wiley & Sons, New York-Toronto. $75.00. 1976.

Mosquitoes are among the most important vectors of disease agents. Therefore information on mosquito ecology is of considerable public health importance. The author of this impressive volume assembled in eleven chapters detailed information on various species of adult mosquitoes as well as of their eggs and larvae. The chapters dealing with the marking, release, and recapture of mosquitoes, as well as the estimation of total insect populations, described in detail, as well as the dispersal, longevity, and calculation of reproductive potential will be among the topics of special interest to those studying mosquito population dynamics. Numerous diagrams and illustrations of trays, traps, and aspirators have been included. Sampling the egg, larval, and adult population, the trapping of adults with non-attractants, with animal-baited, carbon dioxide, and sound traps, sampling of adult population, experimental hut techniques for evaluation of insecticides, recapture techniques, estimation of mortalities, and indices of association between species and species diversity are masterfully presented. The book is aimed at field workers as well as at population researchers and ecologists. Its clarity and good quality of illustrations will be welcomed by all readers. The indexing is adequate.

The book is highly recommended for teachers, students, and for college and experimental station libraries, as well as for individuals—if they can afford it.

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